

Lab 1. Transmission Lines

Name: _____

Section: _____

Task 1. Troubles with the network analyzer

You've just started working as an engineer for a company and on your first day at work you are asked to measure the input impedance of a custom designed device at 80 MHz. You would normally use the network analyzer however it is out of order. The impedance is needed urgently and it is not advisable that you wait until the network analyzer gets repaired. In the lab, you find a 2-m long, 50- Ω slotted coaxial cable and this gives you an idea of how to save the day.

Your idea is to measure the voltage standing wave pattern on the slotted cable at 80 MHz when the cable is terminated in the custom designed device. The load impedance can be deduced from the standing wave pattern.

You connect the device to be measured to an AC voltage generator using the slotted coaxial cable. Then, you send an 80-MHz signal to the device and measure the voltage at multiple equidistant points on the coaxial cable. From the measurement data, you compute the impedance of the custom designed device.

Now, your boss is convinced that the company has hired the right person!

To complete the assignment:

1. Call the user defined MATLAB function *voltage* to simulate the process of taking measurements on the transmission line. Note: You need to have this function in your current MATLAB directory to be able to call it.
2. Make sure you've specified a suitable distance (step) between the points of measurement.
3. Print out the measurements graph generated by *voltage.m* and get your TA signature on it.
4. Analyze the data obtained from the measurement and determine the parameters of the standing wave pattern.
5. Fill in the Task Report Questionnaire.
6. Staple the graph to this report.
7. **Show all your work, to receive full credit.**

Task 1. Troubles with the network analyzer**Questionnaire**

Give brief but accurate and thorough explanation if necessary. Provide math expressions where needed to show how you've obtained the particular result.

1. What is the distance from the load to the first extreme of the standing wave pattern? Specify whether the extreme is a minimum or a maximum.

2. What is the wavelength of the signal on the transmission line?

3. What is the velocity of the wave on the transmission line?

4. What is the voltage standing wave ratio on the line?

5. What is the voltage reflection coefficient at the load?

6. What is the load impedance?
7. What is the resistive part of the load impedance?
8. What is the reactive part of the load impedance? Specify whether it is capacitive or inductive.
9. If you were using a 1-m long coaxial cable, what problem would have arisen?

Task 2. The Big Game on Cable TV

You've just started working as a support engineer for the local Cable TV provider the week before the Penn State–Michigan football game. The morning of the big game, the signal to the west side of town suddenly goes down and there are 5000 dead TV screens and many angry customers. You are sent out to try to diagnose and fix the problem as soon as possible. It turns out that something has crushed the line, but not severed it. That's small relief, though...there's only 1 hour left before the game and the front office has just called you indicating that the town folk are getting really angry. And, you cannot get at the part of the line that has been crushed. You've got to come up with a fix soon.

With so little time left, there is not enough time to splice in a whole new line because you cannot get to the crush location. You decide to take a risk: you slice the line where you can get to it and make a series of measurements. You note that the cable feeding the signal is an RG-6 cable made by Belden, with a characteristic impedance of $75\ \Omega$. The big game is on Channel 4, which has a video signal centered at 67.25 MHz. You determine that at the frequency of Channel 4, the line with the crush, rather than looking like a $75\text{-}\Omega$ load like it should, looks like a load of $(112.5 - j172.5)\ \Omega$.

Your idea is to connect a single stub tuner for Channel 4, since that is the most important signal to get through at the moment.

You find in the stock room a piece of RG-6 cable and decide to use it for the shorted stub. You quickly look up the properties of the cable: the characteristic impedance is $75\ \Omega$, the velocity of propagation (relative with respect to the speed of light in vacuum) is 83%. Using Smith chart you quickly determine how far **back** from the slice (toward the generator) you need to connect the stub and what length of cable you need for the stub.

With the stub in place, and the angry phone calls subsiding, you can now take a breather and spend some time figuring out how to fix the cable for real. But, you decide to wait until *after* the game!

To complete the assignment:

1. Don't forget that Smith chart works only with normalized quantities.
2. When adding a stub in parallel, it's easier to work with admittances.
3. Use a Smith chart to find the distance from the slice to the point of connection.
4. Then, again using Smith chart, compute the length of the stub.
5. On the Smith chart, clearly indicate the points representing the applicable impedances and admittances and the points between which you measure the distances. Ask your TA to sign your Smith chart with your work on it.
6. Don't forget to convert your results in physical lengths (in meters).
7. Fill in the Task Report Questionnaire.
8. Staple the Smith chart (with your work on it) to this booklet. **Show all your work, to receive full credit.**

Task 2. The Big Game on Cable TV**Questionnaire**

Give brief but accurate and thorough explanation if necessary. Provide math expressions where needed. Type your responses.

1. What is the wavelength of the signal on the transmission line?

2. From the Smith chart, what is the normalized load admittance?

3. From the Smith chart, what is the **normalized** admittance of the main transmission line at the point where the shorted stub is to be placed **before** the stub is connected?

4. What is the admittance (in Ω^{-1}) of the main transmission line at the point where the shorted stub is to be placed **before** the stub is connected?

5. What is the admittance (in Ω^{-1}) of the main transmission line at the point where the shorted stub is placed **after** the stub is connected?

6. What must the input admittance (in Ω^{-1}) of the shorted stub be?

7. How far **back** (in meters) from the slice (toward the generator) you need to place the matching stub?

8. What length of cable (in meters) will you need for the stub?

9. Channel 4 is not the only channel that is being transmitted via this cable. The other channels have signals at frequencies that are different from the frequency of Channel 4. What will happen to the other channels after you have fixed the problem with Channel 4? Will the customers be able to watch the program on those channels and why?

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In one or two sentences, explain how you are going to fix the problem.
